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SOME PROBLEMS OF THE PACIFIC FLORAS

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No botanist, who is at all acquainted with the rich and varied floras of the different regions of the great Pacific area, can fail to be impressed with the numerous important problems that present themselves—many of which have as yet received but scant attention. Perhaps most important of all are those dealing with the origin and distribution of these rich floras.

First, and perhaps foremost, is the collecting of data for a study of the relationships existing between the floras of the great Continental areas of the Southern Hemisphere, viz.: Australasia, South America, and South Africa. These areas, so completely separate at present, nevertheless show such similarities as to suggest a common origin for many of their elements. Such a study involves a consideration of the existing floras, which are pretty well known, but also an investigation of the fossil floras, in regard to which we are by no means so well informed as might be wished. Perhaps the fossils collected in the recent Antarctic Expeditions may help us, and, of course, the investigations of the geologists in regard to possible former land connections must be taken into account.

Second, a study of the floras of the innumerable islands of the Pacific should afford much material for many important generalizations. While our knowledge of the special floras—e.g., of the Galapagos Islands and Hawaii, is reasonably complete, there remains room for work concerning the origin of these floras and their later evolution.

The Hawaiian Islands, especially, offer what is probably the most favorable field in the world for the study of the evolution of plant forms. Hillebrand, in his excellent *Flora of the Hawaiian Islands* gives in the introduction (unfortunately left uncompleted by his untimely death), some most valuable suggestions of the possibilities afforded by a study of the flora of Hawaii. It is possible that further work has been done in regard to this matter since Hillebrand's, but if so, I am not acquainted with it. It is generally believed that these islands have always been thus isolated, and while this is not universally admitted, at any rate any former land connections must have been of a very remote period.

A most striking feature of Hawaii is the different ages of the islands which have been formed in succession, beginning with Kauai at the northern end of the group. The next and largest island, Hawaii, is still in process of formation.

Hillebrand noted the extremely interesting fact that Kauai, although much smaller than the southern islands, Maui and Hawaii, and with much less range of elevation, is botanically much richer than either of those islands, and contains a much larger proportion of endemic species. It would seem then, that a study of these endemic plants and their distribution in the islands ought to throw much light upon the processes of species formation.

Some of the factors concerned in this remarkable degree of endemism are evident—notably the extreme isolation of the islands; but the agencies that have acted in the islands themselves are not all so clear. The very large percentage of endemic species which, according to Hillebrand, comprises about 80% of the higher plants, suggested to him the possibility of the islands being a centre of special creative energy.

It might be asked perhaps, whether, in newly formed areas, especially those of volcanic origin, there is some factor present which tends to produce variation in plants introduced to them. This is a topic which, as far as I know, has never received attention. It is notorious that volcanic soils are extremely fertile, and some of the richest floras of the world are found in volcanic regions. May it not be possible (this suggestion is offered with some diffidence), that new elements in recent volcanic soils may have an effect, stimulating or otherwise, upon newly introduced plants, causing changes which, fixed by time, result in new species. This is a topic which the numerous volcanic islands of the Pacific should help to elucidate, and one which it seems would be quite worth while investigating.

This question was suggested by observations which I made a few years ago while collecting liverworts in the Malayan region. In Java, which is entirely volcanic in its formation, the liverworts, as well as other types of vegetation reach an astonishing development, both in number and variety, and a comparison of other regions where these plants abound, shows that most of them are volcanic—e.g., Hawaii, New Zealand, the Philippines, Sumatra, and Japan. On the other hand, the granitic formations of the Malay Peninsula and North Borneo, climatically quite similar to Japan and Sumatra, are noticeably deficient in liverworts.

Third, the agencies by which plants reach such remote regions as the Hawaiian Islands, for example, have been repeatedly studied, but very much can still be done, and apparently the amount of accurate experimental work in this direction is not large. Hillebrand thinks a most important agency is that of certain birds. He mentions specially, a species of plover, and the tropic bird. As is well known, Darwin brings out this point, having examined the mud adherent to the feet of certain migratory birds, in which be found seeds of many kinds. A complete investigation of this topic would probably be worth while. The rôle of air and water currents as agencies in plant distribution, still affords a large field for investigation.

In connection with the study of the island floras, especially those of the volcanic islands, it would be very desirable to have careful observations made on the reëstablishment of the vegetation on areas covered by recent volcanic ash or lava. Such observations, for example, as those made upon Krakatoa after the great eruption of 1883. It would probably not be possible to find so complete a sterilization of a whole island as was then the case, but if by chance any similar occasion should arise, the opportunity should certainly not be lost.

The study of the reëstablishment of the vegetation on such a sterilized area would be of great scientific value; and probably results quite worth while might be had from an investigation of the development of vegetation on less extensive new lava flows, or areas covered with fresh volcanic ash. By such studies it might be possible to determine what effects, if any, are produced upon plants growing in lava or ash, of different chemical or physical properties.

The Pacific Coast of America, both north and south, offers many interesting problems, dealing with various phases of plant origin and distribution, and probably California would prove the richest field for such studies.

Aside from the question of variation in the native plants, and the reasons for the high percentage of endemism involving the question of mutation, etc., there are various other points to be considered. If California, like Hawaii, is to be looked upon as a centre of 'formative activity,' the reasons for this need to be carefully and thoroughly investigated.

California has received additions to its flora both from the north and from the south; and there is much to be learned as to the means by which these immigrants reached California, and just where was the home whence they came. Thus, of the northern elements of the flora there is a small infusion of Asiatic and Eurasian types, such as the Tan-bark Oak, the Giant Equisetum, species of Fritillaria, the Sitka Spruce, Madroño (Arbutus), etc. Probably a thorough study of the fossil plants of the State will throw light on some of these questions, and a beginning has already been made in this direction.

Finally, and this applies to all the regions involved, there is to be taken into account the many species, weeds and cultivated plants, which have been introduced through the agency of man. A study of these immigrants—the origin of most of which can be fairly well ascertained, especially when they have been long established in their new habitat—ought to be one of the best means of determining the effects, if any, of a changed environment. The vexed question of the inheritance of such acquired changes can thus be studied on a large scale and under normal conditions. It is surprising that so little attention has been paid to this great field by the many students of mutation and genetics who set the fashions in biology just now.

These are but a few of the many problems which might be undertaken by the botanist in this vast region which it is proposed to explore. It is perhaps presumptuous for one whose work has been mainly in other directions, to suggest what are the most important lines of work in fields in which he is very much of an amateur.

NERVOUS TRANSMISSION IN SEA-ANEMONES

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The retraction of a sea-anemone like Metridium can be accomplished by stimulating mechanically almost any point on its exterior. Hence there must be nervous connections between all points on the surface open to stimulation and the longitudinal muscles of the mesenteries by which retraction is brought about. To ascertain how extensive these connections are, the following experiments were tried. The column wall of a Metridium was completely girdled by a cut deep enough to penetrate the wall but not sever the mesenteries. Stimulation of either the oral or pedal portion of the partly divided animal resulted in general retraction. Complete removal of the oral half left the pedal half capable of retraction. Tongues of column wall cut in any direction and as long as five centimeters transmit when stimulated at their free ends to the longitudinal muscles thus causing retraction. If a Metridium is cut through vertically except for the pedal disc or a piece of the column or the oral disc, the stimulation of one piece will cause the whole animal to retract. If an oblong outline is cut on the column wall so that the encircled area remains attached to the rest of the animal only by the mesenteries, stimulation of this area is followed